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Acceptability of Lignin-Sulfonates by Dairy Cows

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INTRODUCTION

Lignin-sulfonates are the ammonium, sodium, calcium, and magnesium salts of the extract of spent sulfite liquor derived from sulfite digestion of wood. These by-products of the paper milling industry have excellent qualities as pellet binders.[1] They may be used under the Federal Food, Drug and Cosmetic Act as a sole pelleting aid in feeds in maximum amount of 4%.[2]

EXPERIMENTAL PROCEDURE AND RESULTS

In the experiments described below, the palatability of ammonium salts of the lignin-sulfonates from two sources were studied in dairy cows. Two percent lignin-sulfonate was used in each case and incorporated in a complete concentrate diet for dairy cows (Table 1). The ingredients listed in Table 1 were pelleted and fed twice daily as the sole concentrate feeds. Hay and corn silage were also fed as 40% and 20% respectively of the daily ration.

Three kinds of experiments were conducted. In the first trial, cows were shifted directly from a non-pelleted control diet containing no lignin-sulfonate to a pelleted diet which contained 2% lignin-sulfonate. The control group of cows was shifted to a similar but pelleted diet.

A single feeding of the concentrate was placed before each cow at 4 a.m. This ranged between 11 and 16 lb. for each cow. After 2

[1]Pfost, H. B. 1962. Pelleting Wheat Mill Feeds. Bull., Assoc. of Operative Millers, pp. 2655-2656.

[2]Anonymous. 1962. Food Additives. Lignin Sulfonates in Animal Feeds. Federal Register 27, 8423.

TABLE 1.—Ingredients in Grain-Concentrate Rations (Percent of Total).

	Control Concentrate	Experimental Concentrate
Ground Corn	50.0	49.0
Ground Oats	20.0	19.6
Soybean Meal	27.4	26.8
Steamed Bonemeal	2.0	2.0
Iodized Salt	0.6	0.6
Lignin-Sulfonate (Ammonium)	—	2.0

TABLE 2.—Experiment 1: On the Average, Cows Adapted Rapidly to Diets Containing 2% Lignin-Sulfonate, Consuming a Single Meal of Grain Concentrate Within 2 Hours.

Day	Control Diet (D-113)			2% Lignin-Sulfonate Added (D-217)		
	Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.
	lb.	lb.	%	lb.	lb.	%
	Group 1			Group 2		
1	13.7	0.01	0.09	13.8	1.12	9.49
2	13.7	0.34	2.87	13.8	1.13	9.82
3	13.7	0.08	0.75	13.8	0.73	5.48
	Group 2			Group 1		
4	13.8	0.51	4.23	13.7	0.07	0.69
5	13.8	0.52	3.75	13.7	0.11	1.00
6	13.8	0.19	1.45	13.7	0.47	3.46

TABLE 3.—On the Average, Cows Fed 2% Lignin-Sulfonate Ate Their Grain-Concentrate Allowance Over a More Extended Period But Consumed Essentially an Equal Amount of Dry Matter Daily.

Source	Control Diet (D-113)				2% Lignin-Sulfonate Added (D-217)			
	Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake	Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake
	lb.	lb.	%	lb.	lb.	lb.	%	lb.
Mehoopany (40 Trials)	13.65	0.28	2.43	48.65	13.65	1.17	10.04	48.47
Green Bay (15 Trials)	14.06	0.14	0.98	50.01	13.93	1.12	9.40	49.26

hours (at 6 a.m.), the total amount of concentrate feed which was left in the manger was weighed, recorded as the 2-hour refusal, and returned to the manger. The amount consumed was calculated by the difference.

The experimental design consisted of a series of switchback trials, in which five cows in a control group and five cows in an experimental group were fed alternately the control diet and the experimental diet containing 2% lignin-sulfonate. Each group of cows was observed daily for 3 days before switching to the alternate diet.

On the average, cows adapted rapidly to diets containing 2% lignin-sulfonate, consuming a single meal of grain-concentrate within 2 hours (Table 2). Detailed information is presented as to the amount of refusal through 6 days of feeding. It will be noted that the average amount of feed not consumed in 2 hours dropped to minimal levels in 3 days and compared favorably with the control diet after that.

On the average, cows fed 2% lignin-sulfonate ate their grain-concentrate allowance over a more extended period but consumed essentially an equal amount of dry matter daily. This is illustrated in Table 3 where it is shown that in the Mehoopany[3] trials, 10.04% of the grain was refused over the 2-hour period compared to 2.43% for the control diet. Similarly, in the Green Bay trials, 9.4% was not consumed in the 2-hour period compared to 0.98% for the control diet. However, it should be noted that the cows ate equivalent amounts of dry matter on both diets. Thus it is concluded that the treatment with 2% lignin-sulfonate did not affect the overall feed intake but did change the habit of the cow consuming it.

The average amount of feed consumed in 3 days in individual cows fed 2% lignin-sulfonate (i.e., for one trial) is shown in Table 4. The amount fed, amount refused in 2 hours, and average dry matter intake are detailed for each of the trials studied.

The cows ate the same amount of dry matter whether they were consuming the control diet or the diet treated with 2% lignin-sulfonate. Further examination shows that many of the cows studied ate both the control diet and lignin-sulfonate equally well during the first 2 hours. However, in six cases cows failed to respond immediately to lignin-sulfonate treatment. This is particularly notable in the case of cow 1361 on Mehoopany treatment, 1692 on Mehoopany treatment, 1697 on Mehoopany treatment, 1793 on Green Bay treatment, 1728 on Green Bay treatment, and 1823 on Mehoopany treatment. Examination of the individual trials, day by day, suggested that the most crucial period was during the first day.

[3]Mehoopany and Green Bay designate the origin of ammonium ligin-sulfonate used.

TABLE 4.—Average Amount of Feed Consumed in 3 Days by Individual Cows Fed 2% Lignin-Sulfonate. Presented as the Amount from a Single Grain-Concentrate Meal Refused and Total Dry Matter Intake Consumed.

Cow No. and Trial	Control Diet (D-113)				2% Lignin-Sulfonate Added (D-217)			
	Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake	Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake
	lb.	lb.	%	lb.	lb.	lb.	%	lb.
		Control				Mehoopany		
H-1361								
Trial 1	11	2.4	22.4	38.7	11	1.7	15.7	37.4
Trial 2	11	0.8	7.2	41.5	11	1.3	11.8	40.7
Trial 3	11	0.9	8.7	41.8	11	0.4	3.9	38.2
Trial 4	11	0.8	7.8	39.1	11	0.0	0.0	39.1
						Green Bay		
Trial 5	11	0.0	0.0	42.3	11	0.0	0.0	42.6
Trial 6	11	0.0	0.0	34.4	11	0.2	1.8	33.9
		Control				Mehoopany		
H-1692								
Trial 1	15	0.7	4.8	43.3	15	1.4	9.3	42.4
Trial 2	15	0.2	1.3	49.2	15	0.0	0.0	48.8
Trial 3	15	0.0	0.0	49.9	15	0.0	0.0	50.8
Trial 4	15	0.0	0.0	49.2	15	0.0	0.0	48.1
						Green Bay		
Trial 5	15	0.0	0.0	51.1	15	0.0	0.0	50.6
Trial 6	15	0.0	0.0	51.1	15	0.0	0.0	51.7
		Control				Mehoopany		
H-1697								
Trial 1	11	0.0	0.0	39.0	11	2.1	19.8	42.8
Trial 2	11	0.0	0.0	40.6	11	0.0	0.0	44.0
Trial 3	11	0.0	0.0	39.8	11	0.0	0.0	41.1
Trial 4	11	0.0	0.0	39.4	11	0.0	0.0	41.3

TABLE 4 (Continued).—Average Amount of Feed Consumed in 3 Days by Individual Cows Fed 2% Lignin-Sulfonate. Presented as the Amount from a Single Grain-Concentrate Meal Refused and Total Dry Matter Intake Consumed.

Cow No. and Trial	Control Diet (D-113) Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake	2% Lignin-Sulfonate Added (D-217) Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake
	lb.	lb.	%	lb.	lb.	lb.	%	lb.
H-1793						Green Bay		
Trial 5	10	0.0	0.0	39.6	10	7.5	75.0	35.4
Trial 6	10	0.2	1.6	37.9	10	0.6	6.3	38.0
		Control				Mehoopany		
H-1715								
Trial 1	15	0.0	0.0	55.9	15	0.0	0.0	53.3
Trial 2	15	0.0	0.0	58.2	15	0.0	0.0	59.2
Trial 3	15	0.0	0.0	51.9	15	2.5	16.8	50.7
Trial 4	15	1.1	7.5	53.7	15	0.0	0.0	53.2
						Green Bay		
Trial 5	15	0.0	0.0	49.5	15	0.0	0.0	53.0
Trial 6	15	0.0	0.0	54.4	15	0.6	5.3	45.5
		Control				Mehoopany		
H-1728								
Trial 1	15	0.0	0.0	50.3	15	0.0	0.0	52.2
Trial 2	15	0.3	2.2	52.2	15	0.0	0.0	52.9
Trial 3	15	0.0	0.0	51.2	15	0.0	0.0	52.7
Trial 4	15	0.0	0.0	49.1	15	0.0	0.0	49.9
						Green Bay		
Trial 5	15	2.0	13.3	47.6	15	0.5	3.7	47.5
Trial 6	15	2.1	13.9	47.5	15	7.4	49.7	44.4

TABLE 4 (Continued).—Average Amount of Feed Consumed in 3 Days by Individual Cows Fed 2% Lignin-Sulfonate. Presented as the Amount from a Single Grain-Concentrate Meal Refused and Total Dry Matter Intake Consumed.

Cow No. and Trial	Control Diet (D-113)				2% Lignin-Sulfonate Added (D-217)			
	Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake	Av. Grain Fed	Av. Refused in 2 Hr.	Av Not Consumed in 2 Hr.	Av. Dry Matter Intake
	lb.	lb.	%	lb.	lb.	lb.	%	lb.
		Control				Mehoopany		
J-1776								
Trial 1	10	0.0	0.0	36.6	10	0.0	0.0	35.4
Trial 2	10	0.0	0.0	40.3	10	0.0	0.0	41.7
Trial 3	11	0.0	0.0	39.4	11	0.0	0.0	40.7
Trial 4	11	0.0	0.0	42.0	11	0.0	0.0	45.8
						Green Bay		
Trial 5	14	0.0	0.0	54.9	14	0.0	0.0	52.8
Trial 6	14	0.0	0.0	53.4	14	0.0	0.0	52.2
		Control				Mehoopany		
H-1782								
Trial 1	16	0.0	0.0	48.8	16	0.0	0.0	49.2
Trial 2	16	0.0	0.0	52.6	16	0.0	0.0	52.0
Trial 3	16	0.0	0.0	51.9	16	0.0	0.0	51.3
Trial 4	16	0.0	0.0	51.4	16	0.0	0.0	49.7
						Green Bay		
Trial 5	16	0.0	0.0	50.2	16	0.0	0.0	52.5
Trial 6	16	0.0	0.0	50.0	16	0.0	0.0	49.8
		Control				Mehoopany		
H-1801								
Trial 1	16	0.0	0.0	59.7	16	0.0	0.0	58.2
Trial 2	16	0.0	0.0	61.2	16	0.0	0.0	63.2
Trial 3	16	0.0	0.0	61.9	16	0.0	0.0	59.1
Trial 4	16	0.0	0.0	60.5	16	0.0	0.0	61.3

TABLE 4 (Continued).—Average Amount of Feed Consumed in 3 Days by Individual Cows Fed 2% Lignin-Sulfonate. Presented as the Amount from a Single Grain-Concentrate Meal Refused and Total Dry Matter Intake Consumed.

Cow No. and Trial	Control Diet (D-113) Av. Grain Fed	Av. Refused in 2 Hr.	Av. Not Consumed in 2 Hr.	Av. Dry Matter Intake	2% Lignin-Sulfonate Added (D-217) Av. Grain Fed	Av. Refused in 2 Hr.	Av Not Consumed in 2 Hr.	Av. Dry Matter Intake
	lb.	lb.	%	lb.	lb.	lb.	%	lb.
H-1801						Green Bay		
Trial 5	16	0.0	0.0	60.8	16	0.0	0.0	60.4
Trial 6	16	0.2	1.0	60.3	16	0.0	0.0	60.9
		Control				Mehoopany		
H-1823								
Trial 1	12	1.2	10.5	43.5	12	3.4	28.5	45.3
Trial 2	12	3.0	25.0	46.0	12	3.0	28.8	43.6
Trial 3	12	0.0	0.0	47.9	12	1.2	10.5	41.9
Trial 4	12	0.0	0.0	47.6	12	0.6	5.5	43.8
						Green Bay		
Trial 5	13	0.2	1.5	51.4	13	0.1	0.5	52.1
Trial 6	13	0.3	2.2	46.4	13	0.7	5.8	50.3
		Control				Mehoopany		
H-1921								
Trial 1	15	0.0	0.0	52.0	15	0.0	0.0	50.3
Trial 2	15	0.0	0.0	55.5	15	0.0	0.0	57.2
Trial 3	15	0.0	0.0	56.6	15	0.0	0.0	56.8
Trial 4	15	0.0	0.0	58.1	15	0.0	0.0	54.6
						Green Bay		
Trial 5	15	0.0	0.0	60.5	15	0.0	0.0	59.4
Trial 6	15	0.0	0.0	57.4	15	0.0	0.0	52.6

In the second experiment, initial prehension of the feedstuffs was studied, including the choice of a first bite and during the 12-minute period thereafter. The experimental procedure was as follows. Thirty-one cows were offered the two diets simultaneously in 5-lb. lots at the morning feeding. Ten of the cows had previously been accustomed to the pelleted control diet as well as to the diet containing 2% lignin-sulfonate. The feed was placed in the manger by the same person. Alternate cows received the experimental diet first and then the control diet, so that one-half of the cows were offered the experimental diet first and the other half the control diet. Time lapse between the two diets fed to each cow was scheduled to range between 3 and 4 seconds.

The cows were observed carefully and the feed chosen for the first bite was recorded. Twelve minutes after the initial feeding, consumption of the two feedstuffs was observed and recorded. The following day the experiment was replicated, except that cows receiving the experimental diet first on day 1 received the control diet first on day 2.

No real differences were obtained in the preference for first bite by the cows. This result is interpreted as meaning that the first bite represented a random choice or was equally biased because of the balanced experimental design for placing feed into the manger. Since 17 of the cows reversed their order of preference the second day, it is probable that random choice was a major attribute in selection of the first bite. These results are assumed to indicate that smell did not play an essential role in the prehension of the two feedstuffs offered.

The number of cows preferring the control diet and the experimental diet containing 2% lignin-sulfonate during the initial prehension of the pelleted feedstuffs and during the 12-minute period thereafter is presented according to the two groups of cows—those accustomed to lignin-sulfonate and the cows having no previous lignin-sulfonate or pelleted control diet (Table 5). Concerning dietary preference the first 12 minutes, cows accustomed to lignin-sulfonate ate both diets readily and showed no preference. In contrast, cows which had not been introduced to either diet varied in their day 1 and day 2 response. For example, no cows showed preference to the lignin-sulfonate diet on day 1 (12 cows preferred the control diet and consumed it in its entirety in 12 minutes). Nine other cows refused both kinds. By day 2, this picture had changed and the number of cows preferring the control diet declined to 7, those which consumed both diets increased from 0 to 11, and the number which refused to eat either diet during the first 12 minutes beyond the first bite had dropped from 9 of 21 to 3 of 21 cows.

The second experiment bears out the earlier observation that cows soon become accustomed to lignin-sulfonate in the diet. A certain num-

TABLE 5.—Number of Cows Preferring a Control Diet and a Similar Diet Containing 2% Lignin-Sulfonate During the Initial Prehension of Pelleted Feedstuffs and During the 12-Minute Period Thereafter.

Previous Feeding History	First Bite		Preference for the First 12 Min.	
	Day 1	Day 2	Day 1	Day 2
A. Cows Accustomed to Lignin-Sulfonate	10	10	10	10
1. Preferred Control Diet	6	4	0	0
2. Preferred 2% Lignin-Sulfonate Diet	4	6	0	0
3. Consumed Both (No Differentiation)	N.A.*	N.A.	10	10
B. Cows Having No Previous Lignin-Sulfonate or Pelleted Control Diet	21	21	21	21
1. Preferred Control Diet	11	11	12	7
2. Preferred 2% Lignin-Sulfonate Diet	10	10	0	0
3. Consumed Both (No Differentiation)	N.A.	N.A.	0	11
4. Consumed Neither After Initial Bite	N.A.	N.A.	9	3

*Not applicable.

TABLE 6.—Average Meal Size and Meal Length Were Not Notably Affected After Second Day on Diets Containing Lignin-Sulfonate.

Diet	Date	Days on Lignin-Sulfonate	Total Meals			Initial Meals*			Spontaneous Meals		
			No.	Length (min.)	Size (lb.)	No.	Length (min.)	Size (lb.)	No.	Length (min.)	Size (lb.)
Lignin-Sulfonate (Mehoopany)											
	9/12	2	22	7.3	1.44	2	17.0	3.65	20	6.4	1.02
	9/15	5	16	11.1	1.89	2	32.0	7.95	14	8.0	1.01
	Av.		19	9.2	1.66	2	24.5	6.80	17	7.2	1.01
Lignin-Sulfonate (Green Bay)											
	9/16	6	15	11.3	2.02	2	28.5	8.30	13	8.7	1.06
	9/23	4	14	9.5	1.59	2	18.5	5.65	12	8.0	1.39
	Av.		14.5	10.4	1.80	2	23.5	6.98	12.5	8.3	1.22
Control											
	9/17	0	14	16.3	2.12	2	32.5	9.54	12	13.8	0.88
	9/18	0	15	8.3	1.71	2	16.0	4.42	13	7.2	1.02
	Av		14.5	12.3	1.92	2	24.3	6.98	12.5	10.5	0.95

*First meal after feeding.

ber of cows take an extended period to eat it during the first day that it is fed. It is notable also that on the first day 9 cows refused both diets, indicating that there was considerable rejection of the pelleted form of diet on its first presentation to cows which had not eaten pelleted rations previously. Apparently the taste component of the diet was the sensory unit which became adapted quickly to lignin-sulfonate in the food.

In the third experiment, meal habits of cows were studied. In this case, the experimental cow was given free access to her total ration which contained either 40% by dry weight of the 2% lignin-sulfonate concentrate used in the previous experiment or the control diet. The cow was allowed free access to the manger at all times. The manger was equipped with a pressure transducer and a recorder to record the time required to eat a meal and measure the amount of food eaten during the meal. The average meal size, meal length, and the number of meals were determined for each diet on two different days.

Table 6 shows that the average meal size and the meal length were not notably affected after the second day on diets containing lignin-sulfonate. It appears that on the first day (September 12) when the cow was receiving lignin-sulfonate from the Mehoopany source, the number of meals increased. Also, meal length was shorter and meal size was smaller. This is primarily attributable to the smaller average meal size of the initial meals after feeding. It is obvious that the spontaneous effects on both meal length and meal size were much greater than the effects of the dietary treatments.

SUMMARY

The effects of adding 2% lignin-sulfonate to the diet are cursory. Cows require a short length of time to become accustomed to it. This is a 1 to 3 day period but primarily a factor on the first day only. No severe limitation on the total dry matter intake consumed by cows was observed in any case. Therefore, it is concluded that the addition of lignin-sulfonate is not a measurable factor affecting performance of dairy cows.

It was concluded that ammonium salts of lignin-sulfonates may be used in dairy cattle rations up to 2% of the grain concentrate without adversely affecting the feed intake of these cows.

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Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres